Scientific Inquiry

8-1 The student will demonstrate an understanding of technological design and scientific inquiry, including process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

8-1.1 Design a controlled scientific investigation.
Taxonomy Level: 6.2-C Create Procedural Knowledge

Previous/Future knowledge: In 4th grade (4-1.3), students summarized the characteristics of a simple scientific investigation that represent a fair test (including a question that identifies the problem, a prediction that indicates a possible outcome, a process that tests one manipulated variable at a time, and results that are communicated and explained). In 5th grade (5-1.3), students planned and conducted controlled scientific investigations, manipulating one variable at a time. In 7th grade, students explained the reasons for testing one independent variable at a time in a controlled scientific investigation (7-1.3) and explained the importance that repeated trials and a well-chosen sample size have with regard to the validity of a controlled scientific investigation (7-1.4).

It is essential for students to know that a *controlled scientific investigation* determines the effect of an independent variable in an experiment, when all other variables are controlled. Every controlled scientific investigation provides information. This information is called *data*. Data includes both scientific observations and inferences.

- A *scientific observation* is gained by carefully identifying and describing properties using the five senses or scientific tools and can be classified as *quantitative* or *qualitative*.
  - Quantitative observations are observations that use numbers (amounts) or measurements (including the unit label) or observations that make relative comparisons, such as more than, all, less than, few, or none.
  - Qualitative observations are observations that are made using only the senses and refer to specific properties.
- An *inference* is an explanation or interpretation of an observation based on prior experiences or supported by observations made in the investigation. They are not final explanations of the observation. There may be several logical inferences for a given observation. There is no way to be sure which inference best explains the observation without further investigation.

In order to design a *controlled scientific investigation* some or all of the following steps should be included:

- Identify a testable question (tests one variable) that can be investigated
- Research information about the topic
- State the hypothesis as a predicted answer to the question, what may be the possible outcome of the investigation
- Design an experiment to test the hypothesis, controlling all variables except the independent variable
  - Plan for independent and dependent variables with repeated trials
  - Plan for factors that should be held constant (controlled variables) and/or plan for a control set-up
  - List the materials needed to conduct the experiment
  - List the procedures to be followed
  - Plan for recording, organizing and analyzing data
- Conduct the experiment and record data (observations) in tables, graphs, or charts
- Analyze the data in the tables, graphs, or charts to figure out what the data means (describe the relationship between the variables)

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- Compare the results to the hypothesis and write a conclusion that will support or not support the hypothesis based on the recorded data
- Communicate the results to others
  - Share conclusions and make recommendations for further study

NOTE TO TEACHER: The use of the terms manipulated variable and responding variable are no longer essential. Teachers may continue to reference these terms, but students will not be held accountable in testing. However, it is essential for students to use the terms independent variable and dependent variable.

It is also essential for students to know that science is the process of learning about the natural world by asking questions and trying to find the answers to those questions. Technology applies scientific knowledge in order to develop a solution to a problem or create a product to help meet human needs. Technology is usually developed because there is a need or a problem that needs to be solved. Steps in the technological design process include:

- *Identifying a problem or need*
  - Research and gather information on what is already known about the problem or need
- *Designing a solution or a product*
  - Generate ideas on possible solutions or products
  - Evaluate the factors that will limit or restrict the solution or product design
  - Determine the trade-offs of the solutions or products (what must be given up in order to create the solution or product)
- *Implementing the design*
  - Build and test the solution or product
  - Identify any problems with the solution or product
  - If necessary, redesign the solution or product to eliminate any problems in the design
- *Evaluating the solution or the product*
  - Determine if the solution or product solved the problem
  - Identify the pros and cons of the solution or product

The steps of the design can be communicated using descriptions, models, and drawings.

- A *scientific model* is an idea that allows us to create explanations of how the something may work. Models can be physical or mental.

It is not essential for students to develop a problem statement instead of a question for an investigation, evaluate an investigation as to how it was planned and conducted, or understand a null hypothesis. Students do not need to compare the processes of a controlled scientific investigation and the technological design process or evaluate a technological design or product on the basis of designated criteria (including cost, time, and materials).

Assessment Guidelines

The objective of this indicator is to *design* a controlled scientific investigation; therefore, the primary focus of assessment should be to devise a plan for conducting a science investigation that tests only one variable at a time. However, appropriate assessments should also require students to *recognize* steps appropriate for conducting a controlled investigation; *detect* inappropriate steps in a given investigation; *organize* the results of the investigation in tables or charts; *classify* by sequencing the steps of a controlled scientific investigation; or *summarize* the steps in a controlled scientific investigation.

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